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# Tissue Culture On-chip Design using Multivariable Molecular Network

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## Abstract

This paper proposed tissue culture on-chip design using multivariable molecular network by using three network combinations such as star, bus and ring networks. A chip consists of star networks that allow the trapping molecule (nutrient or gene) circulation within design a circuit. In principle, the required nutrient can be trapped by the multivariable tweezers and transported to the required destinations. PANDA ring resonator is a modified add-drop filter can be generated and the molecules trapping transport is reviewed. In this work we are seeking for the optimizing results, which will be considered by choosing the suitable network parameters.

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Open access under [CC BY-NC-ND license](https://creativecommons.org/licenses/by-nc-nd/4.0/).**Keywords:** Multivariable molecular network; tissue culture; trapping molecule

## 1. Introduction

Up to date artificial organs is very popular research field as seen from a numerous effort in artificial organs researches for example a living system on a chip [1], stem cells on chip [2], blood cleaner on-chip [3]. The tissue culture, however, was the first proposed and confirmed in 1907 by Ross Granville Harrison. Then a living system on a chip is invented in 2011 by Monya baker which combines cells and nanotechnology to reconstruct tissues, organs and stem cell. The chip showed that the cells' behavior changes when they are stretched. The blood cleaner on-chip was proposed by Suwanpayak et al., the blood waste and unwanted substances can be trapped and transported or filtered from the artificial human

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kidney, which the required trapping tool sizes can be generated and formed for the specific blood waste molecules, and finally the clean blood can be obtained and sent to the destination. Although there are many aspects of researches on-chip, but tissue culture on-chip is rarely investigation. In this paper, we propose the tissue culture on-chip using multivariable molecular network by using star network, the dynamic optical tweezers/vortices are generated and controlled by Gaussian pulse propagating within an add/drop optical multiplexer incorporating two nanoring resonators called “PANDA” in order to transported nutrient to the tissue culture on-chip while the waste was removed from the chip. The advantage of proposed system, the required nutrient can be trapped by the multivariable tweezers and transported to the required destinations. By using tissue culture on-chip in situ surgery can be provided.

## 2. Principles

In theory, the trapping forces are exerted by the intensity gradients in the strongly focused beams of light to trap and move the microscopic volumes of matters, in which the optical forces are customarily defined by the relationship [4].

$$F = \frac{Qn_m P}{c} \quad (1)$$

Here  $Q$  is a dimensionless efficiency,  $n_m$  is the index of refraction of the suspending medium,  $c$  is the speed of light, and  $P$  is the incident laser power, measured at the specimen.  $Q$  represents the fraction of power utilized to exert force. For plane wave incident on a perfectly absorbing particle,  $Q$  is equal to 1. To achieve stable trapping, the radiation pressure must create a stable, three-dimensional equilibrium. Because biological specimens are usually contained in aqueous medium, the dependence of  $F$  on  $n_m$  can rarely be exploited to achieve higher trapping forces. Increasing the laser power is possible, but only over a limited range due to the possibility of optical damage.  $Q$  itself is therefore the main determinant of trapping force. Furthermore, in the Rayleigh regime, the trapping forces decompose naturally into two components (scattering and gradient force). Since, in this limit, the electromagnetic field is uniform across the dielectric, particles can be treated as induced point dipoles. The scattering ( $F_{scatt}$ ) and the gradient field ( $F_{grad}$ ) is the Lorentz force that acting on the dipole induced by the light field are defined by [4, 5], which can be formed within the tiny system, for instance nanoring resonator.

## 3. Tissue culture on-chip

The proposed system in Fig. 1, the trapping force is formed by using Gaussian pulse is generated and controlled within the PANDA ring resonator [6] by the control port signals. From Fig. 1, the output field ( $E_{tl}$ ) at the through port [7] here  $E_t$  and  $E_d$  represent the optical fields of the through port and drop ports. In the case of the add/drop device, the nonlinear refractive index is not effect to the system, therefore, it is neglected. The electric fields  $E_{\theta}$  and  $E_{\theta L}$  are the field circulated within the nanoring at the right and left side of add/drop optical filter. Molecular buffer is a device that can be used to store or delay nutrient for a period of time where light intensity and velocity can be controlled, which was described by the authors in references [8]. Nanogels/microgel is a coupling material that serves between nanodevice and neural cells (target sites). Moreover, molecules transport within the star networks by nutrient routers, in which the control port is available for additional applications. In additional, the composition of the tissue culture medium is essential, which was developed Eagle's minimal essential medium (Eagle's MEM or

MEM), is still used to maintain tissue culture on-chip. Finally the add/drop filter is used to filter the suitable molecules size to the required nutrient targets.

#### 4. Result

In simulation, the Gaussian pulses with center wavelength at  $1.50\ \mu\text{m}$ , peak power  $2\text{W}$ , pulse  $35\text{fs}$  is input into the system via the input port, and the coupling coefficients are given as  $\kappa_0 = 0.5$ ,  $\kappa_1 = 0.35$ ,  $\kappa_2 = 0.1$ , and  $\kappa_3 = 0.35$ , respectively. The ring radii are  $R_{add} = 20$  and  $1\ \mu\text{m}$ ,  $R_R = 5$  and  $0.8\ \text{nm}$ , and  $R_L = 5$  and  $0.8\ \text{nm}$ , respectively. To date, the evidence of a practical device with radius of approximately  $0.8\ \mu\text{m}$  has been reported by the authors [9] in which  $A_{eff}$  is  $2.01\ \mu\text{m}^2$  ( $r = 800\ \text{nm}$ ). In this case, the dynamic tweezers (gradient fields) can be in the form of Gaussian pulses, bright solitons and dark solitons, which can be used to trap the required microscopic volume. There are four different center wavelengths of tweezers generated; the dynamical movements are seen in Fig. 1, where (a)  $|E_1|^2$ , (b)  $|E_2|^2$ , (c)  $|E_3|^2$ , (d)  $|E_4|^2$ , (e) through port, and (f) drop port signals, where in this case all microscopic volumes are received by the drop port. The important aspect of the result is that the tuneable tweezers can be obtained by tuning (controlling) the add (control) port input signal, in which the required number of single nutrient can be obtained and seen at the drop/through ports. Otherwise, they propagate within a PANDA ring before collapsing/decaying into the waveguide. More results of the optical tweezers generated within the PANDA ring are shown in Fig. 2, the Gaussian pulses is used as the control port signal to obtain the tunable results. The output optical tweezers of the through and drop ports with different coupling constants are as shown in Fig. 2A, while the different wavelength results are as shown in Figure 2B, which can be performed by the selected targets. The trapped microscopic volumes (nutrient) can move into the wavelength router via the through port, while the retrieved microscopic volumes are received via the drop port (connecting target).

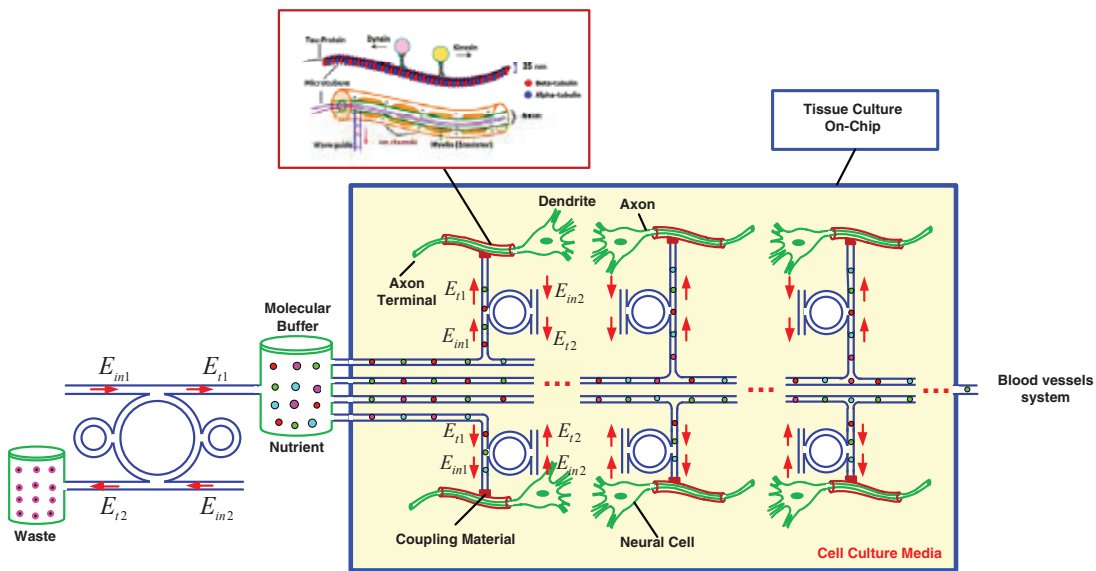


Fig. 1. Schematic diagram of tissue culture on-chip

## 5. Conclusion

We have proposed an interesting system for the tissue culture on-chip. The trapped nutrient molecules can move into the liquid core waveguide and networks by using the optical tweezers, where the nutrient trapping, storage and delivery via the molecular network can be realized. The trapping and movement of nutrient molecules in such system can be used for cell culture purpose to deliver nutrient molecules to the required destinations. By using the practical device parameters, such a proposed system can be fabricated and integrated to be a thin film device for a situ surgery, which can be practiced and implemented.

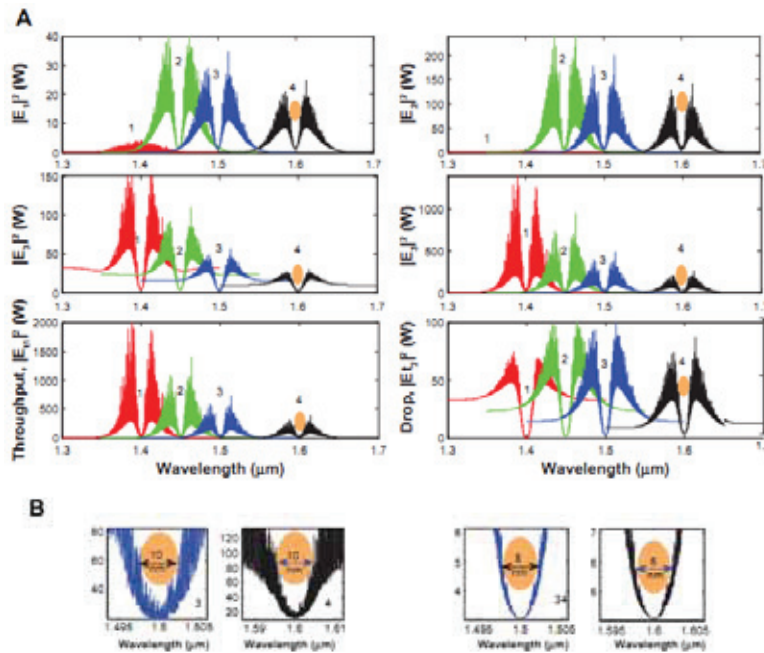


Fig. 2 (A) Results of the trapping tool; (B) different size and wavelengths

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